

Novel In Situ Perchlorate-Based Blasting Agents from Martian Regolith Resources



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Abstract

The lack of blasting capabilities forms a critical gap in resource extraction and excavation on Mars. Native perchlorate salts within the Martian regolith hold potential as *in situ* oxidizers for the manufacture of explosives. Thermochemical simulations identified viable heterogenous explosive mixtures with *in situ* fuels. Sensitivity testing outlined the threshold impact, friction, and electrostatic discharge limits. A small-scale shock experiment further established the ability to detonate these mixtures. These results imply that safe explosive handling and employment procedures could parallel terrestrial practices, supporting the feasibility of *in situ* blasting explosives from repurposed perchlorates in Martian soil.

Motivation

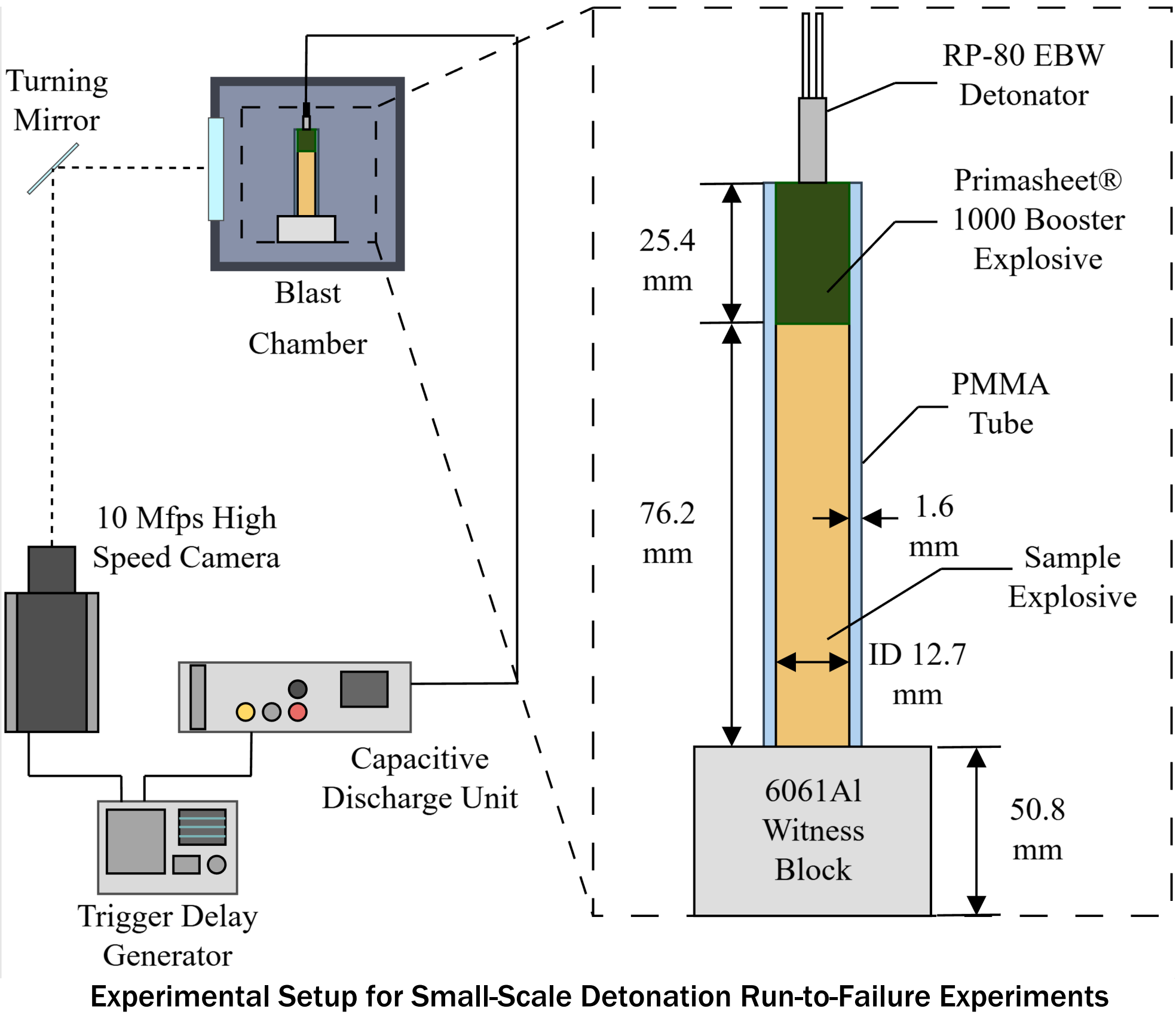
- Centuries of terrestrial mining indicate that blasting capabilities would significantly improve resource acquisition and habitat construction on Mars.
- Manufacture of explosives via *in situ* resource utilization (ISRU) would bypass their expensive and hazardous transit from Earth.
- Globally abundant Mg- and Ca- perchlorate found in regolith could serve as oxidizers for heterogeneous explosives. [1]

Goal:

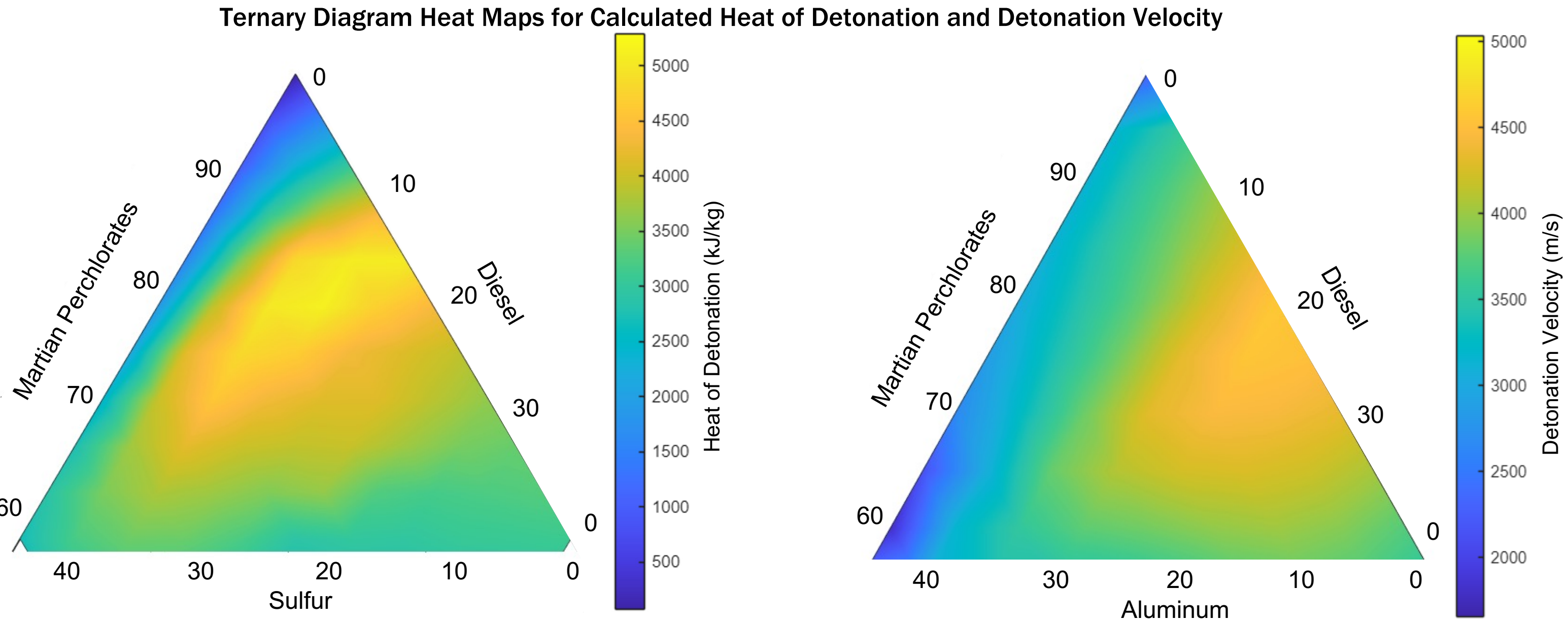
- Identify theoretically high-performing ISRU explosive mixtures
- Experimentally characterize sensitivity and detonability of selected formulations

Methods

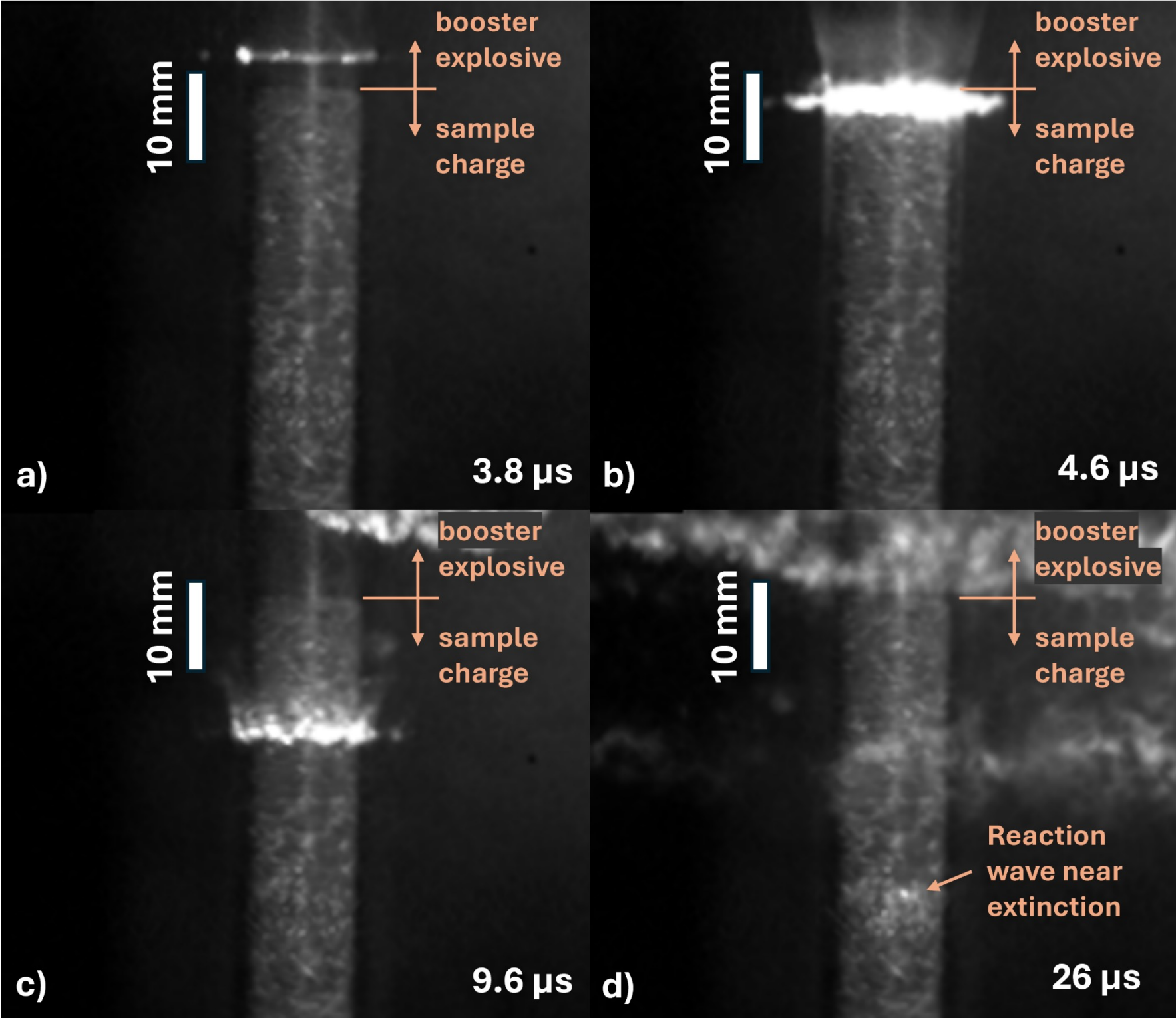
- EXPLO5 thermochemical software simulation of wide array of formulations comprising the Martian perchlorates with sulfur, diesel, and aluminum [2]
- Sensitivity thresholds defined by means of drop weight impact, friction, and electrostatic discharge (ESD) testing
- Small-scale detonation experiments with high-speed imaging to preliminarily assess shock sensitivity and run-to-failure [3]



EXPLO5 Simulation

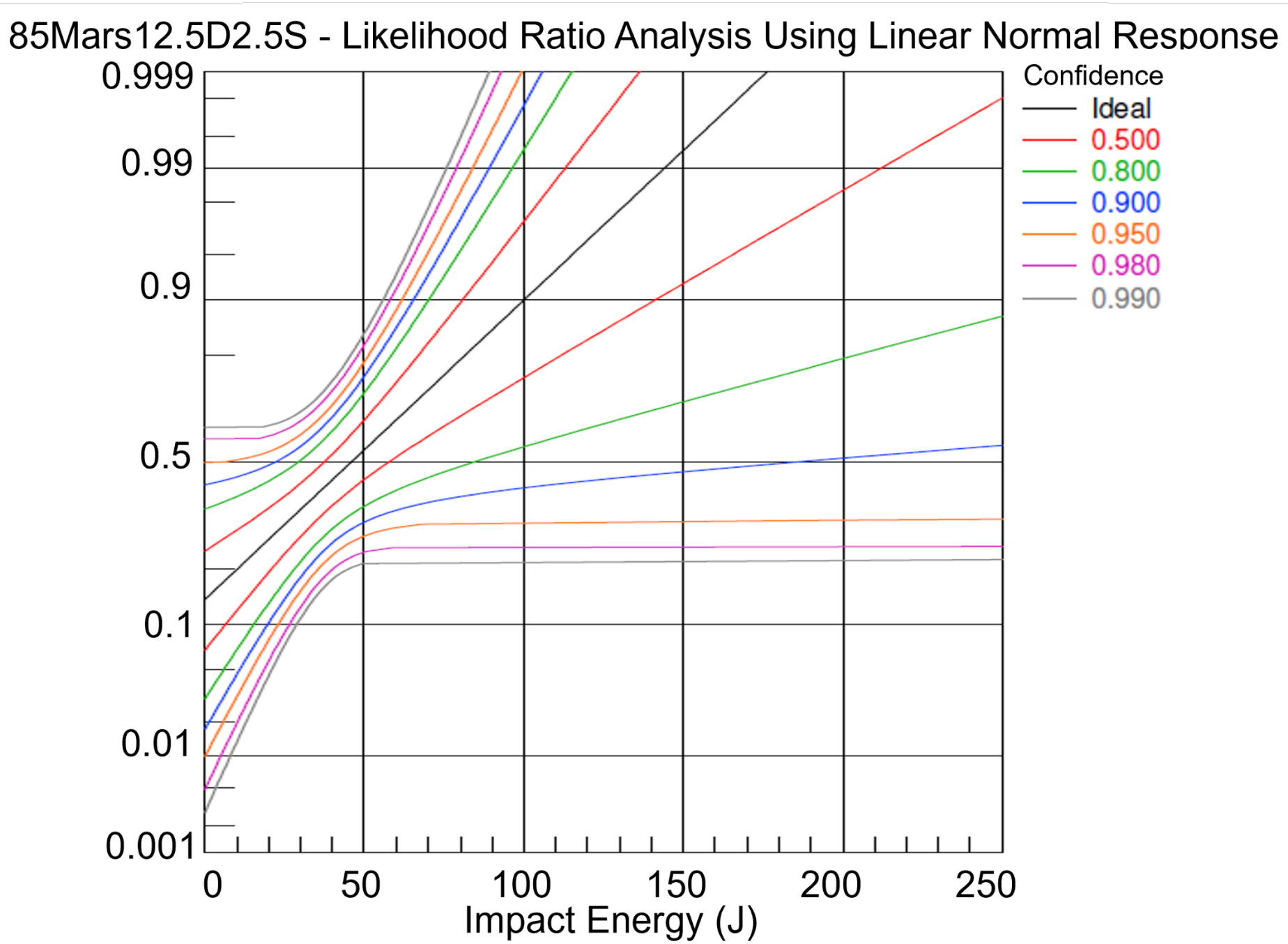
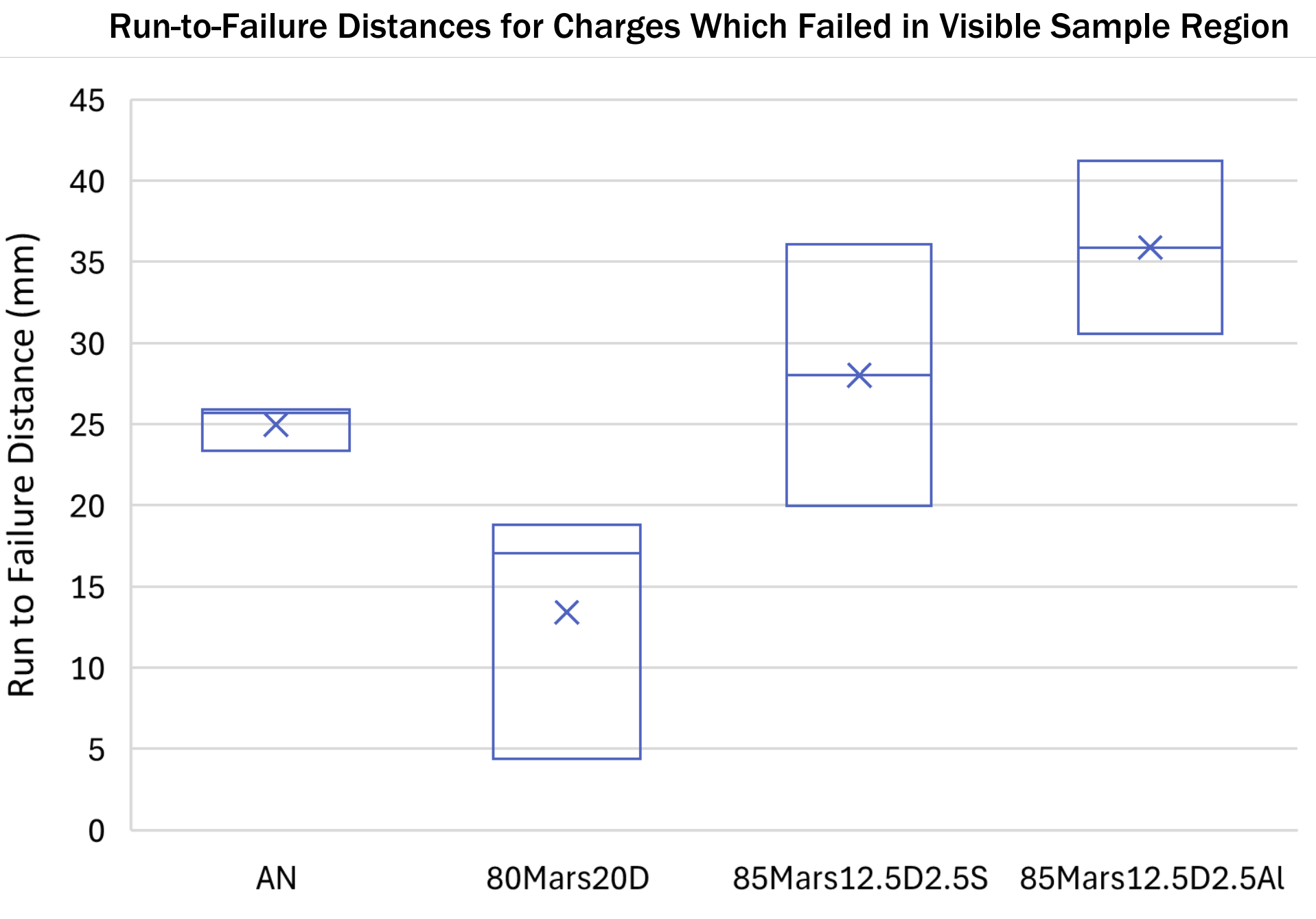
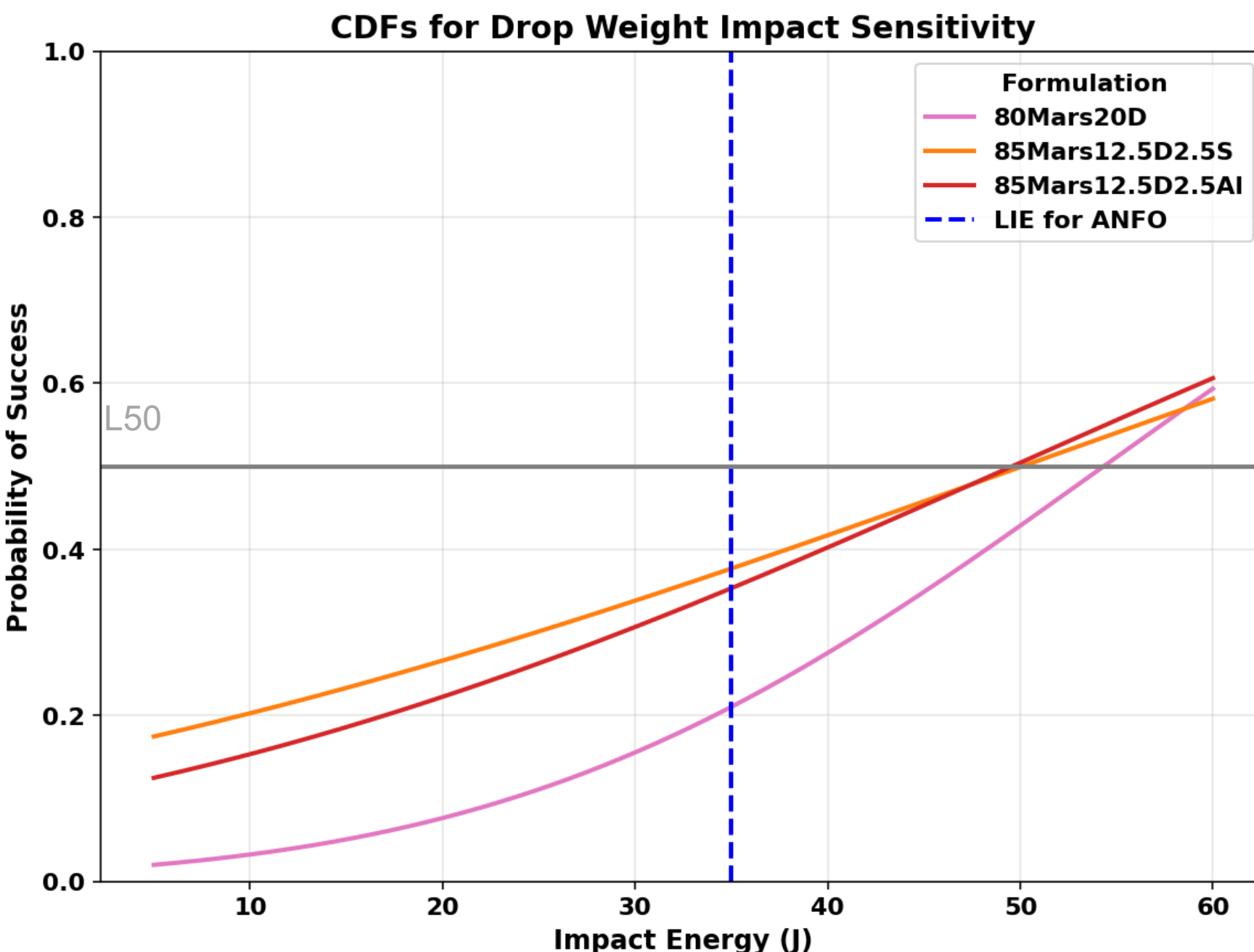


Small-Scale Explosive Testing



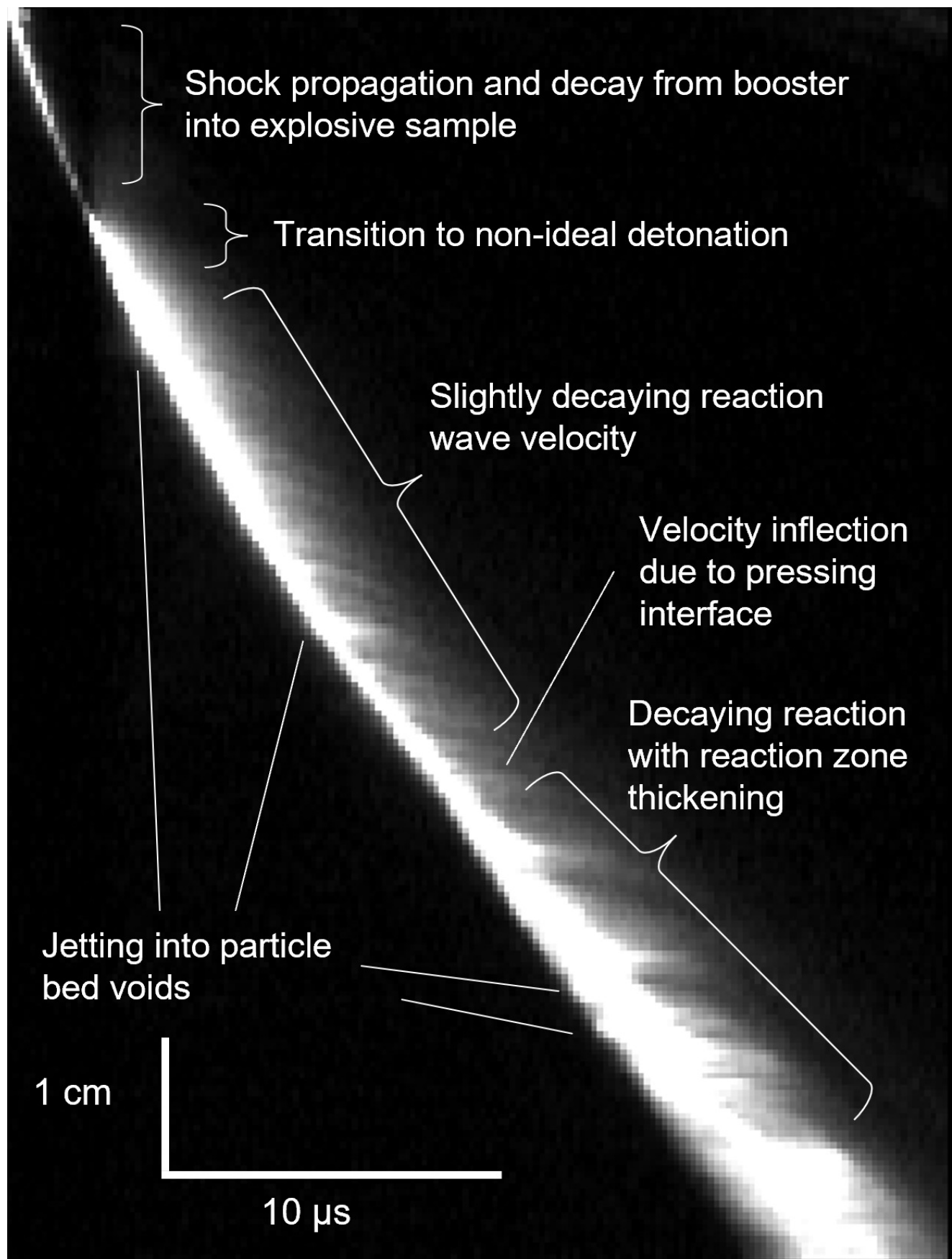
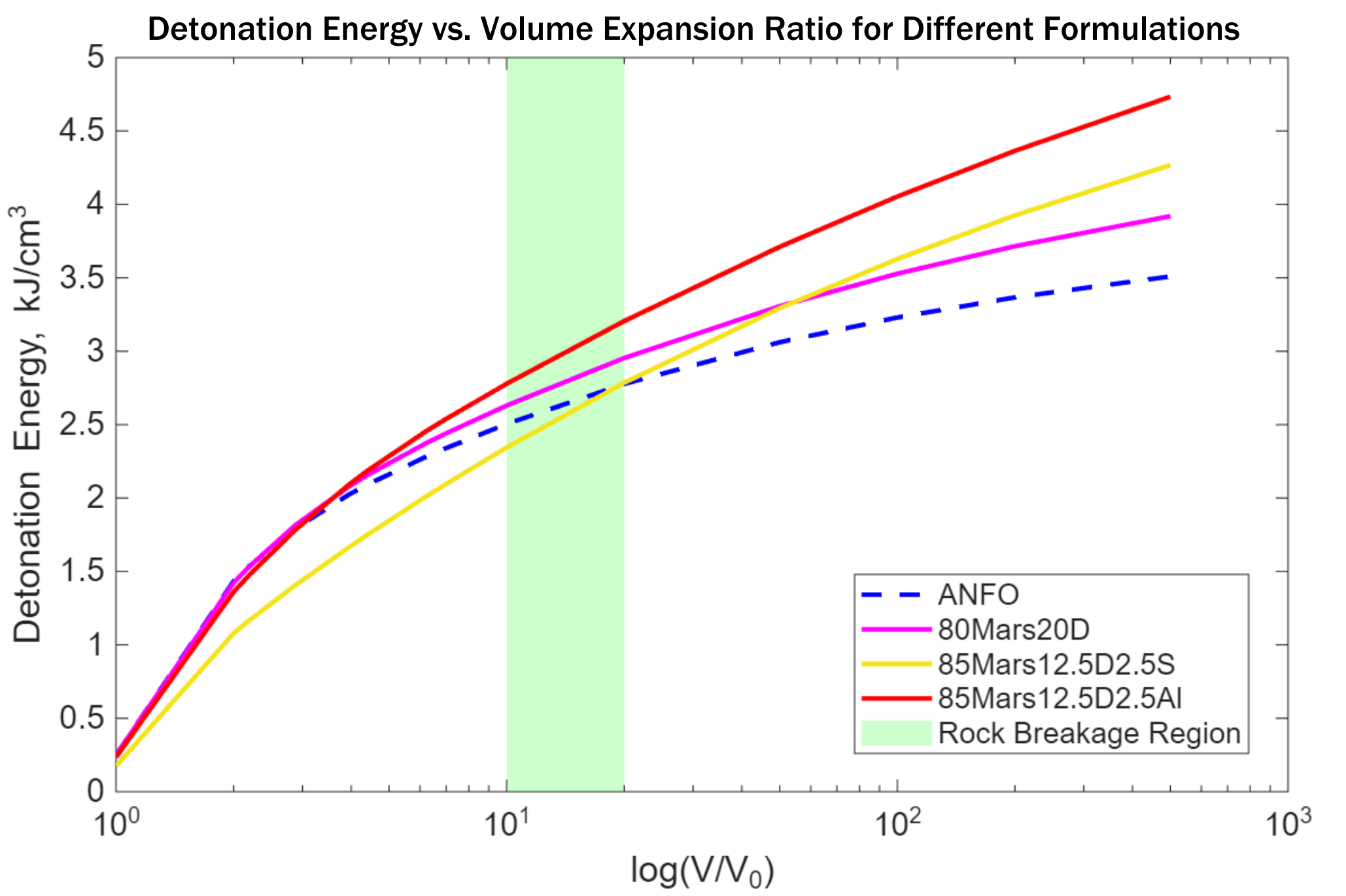
High-Speed Imaging of Reaction Wave Progression Through Sample

Sensitivity Testing



References:

- Clark, B. C., and Kounaves, S. P., "Evidence for the Distribution of Perchlorates on Mars," International Journal of Astrobiology, Vol. 15, No. 4, 2016-10, pp. 311-318.
- Suceska, "EXPLO5 Version V6.06 User's Guide," OZM Research, 2021.
- Scott, D. G., Cummock, N. R., and Son, S. F., "Small-Scale Characterization of Shock Sensitivity for Non-Ideal Explosives Based on Imaging of Detonation Failure Behavior," Propellants, Explosives, Pyrotechnics, Vol. 48, No. 3, 2023-03, p.e202200252



Streak Image of Fully Propagated Detonation Through 85Mars12.5D2.5S Sample

Conclusions

- Mixtures have been shown to have adequate performance with varied compositions
- Rock breaking and expansion work can rival or outperform ANFO, the primary terrestrial blasting explosive
- Explosive blends could primarily consist of the Martian perchlorates with diesel
- Sulfur or aluminum could be added to augment output (expansion work profile, reaction product species, etc.) and significantly sensitize a formulation
- Future studies necessary to investigate heterogeneous explosive effects (density, particle size, confinement)